DOCUMENT RESUME

ED 380 410 SP 035 736

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TITLE The Status of Hand Held Calculators in Secondary Mathematics: An Examination of Issues and Uses in the Classroom throughout the Mid-Hudson Valley Region.
PUB DATE Dec 94
NOTE 59p.
PUB TYPE Reports - Research/Technical (143) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Administrator Attitudes; *Calculators; Educational Media; High Schools; Inservice Teacher Education; *Mathematics Instruction; *Mathematics Teachers; Principals; School Policy; *Secondary School Mathematics; *Teacher Attitudes; *Teaching Methods
IDENTIFIERS Hudson Valley; National Council of Teachers of Mathematics; New York (Upstate)

ABSTRACT

In light of research findings on how calculators can enhance mathematics learning, this study investigated the uses of hand held, non-programmable, scientific calculators in secondary mathematics education throughout the Mid-Hudson Valley (New York). The study gathered data from 18 high school principals and 25 mathematics teachers in 32 school districts. The survey examined calculator usage and was based on the National Council of Teachers of Mathematic's (NCTM) position statement on calculator use in the classroom. Participants supplied information on job description, student population, percentage of students having calculators, percentage of district mathematics programs that integrated calculators into their curricula, the percentage of district math teachers that supported the use of calculators during instruction, calculator use during tests, in-service training, anecdotal information on benefits and problems, district calculator policies, and awareness of the NCTM's recommendations. Analysis of data found: (1) less than 50 percent of mathematics teachers routinely use calculators in classroom instruction; (2) 71.4 percent of the cumulative survey responses reported had no district in-service calculator teacher training available; (3) 77.5 percent of participants reported that the school district provided teacher calculator support; and (4) nearly 88 percent of participants were aware of NCTM's position statement on calculator use. Appendixes contain copies of the survey and correspondence, and tables of data. (Contains 44 references.) (JB)

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The Status of Hand Held Calculators in Secondary Mathematics: An Examination of Issues and Uses in the Classroom throughout the Mid-Hudson Valley Region

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December 1994

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Abstract

Issues and uses of hand held, nonprogrammable, scientific calculators in secondary mathematics education throughout the Mid-Hudson Valley region in upstate New York were investigated. Despite a preponderance of research data that supports the use of calculators as learning tools which enhance student understanding, problem solving, and attitudes towards mathematics, schools have failed to exploit their usage in routine mathematics instruction. Forty-seven school districts were contacted so that their use of scientific calculators in the secondary mathematics curriculum could be studied. Four hypotheses exploring potential reasons for the failure of secondary mathematics teachers to fully integrate scientific calculators into everyday class instruction, following recommendations of the National Council of Teachers of Mathematics, were examined. The hypotheses were tested based upon data acquired from forty-three Mid-Hudson Valley region high school principals/administrators and mathematics teachers. While the results did not statistically support all of the defined hypotheses, descriptive data identifying issues and uses of hand held calculators in the classroom was assimilated. The findings were consistent with, and extended, results of prior research on this topic.

The Status of Hand Held Calculators in Secondary Mathematics: An Examination of Issues and Uses in the Classroom throughout the Mid-Hudson Valley Region

Introduction

The objective of this study was to examine the use of hand held scientific calculators during mathematics instruction in secondary education throughout the Mid-Hudson Valley region of upstate New York. The use of calculators as instructional aids in teaching mathematics has been debated by educators for over the last twenty years. Proponents and opponents have articulated strong feelings for both sides of this issue, yet research, which is cited below, suggests that the use of calculators in mathematics education may benefit student learning. This study examined issues associated with the use of hand held calculators in teaching secondary mathematics and their effects upon student learning. It further investigated issues associated with effectively integrating the use of calculators into existing secondary education mathematics curriculum.

Statement of Problem

Opponents against the use of calculators in math classes have cited a host of issues including: (1) the lack of school policies regarding their usage (Reys, Bestgen, Rybolt, & Wyatt 1980), (2) equity in testing (Harvey, 1991; Kenelly, 1990; Loyd, 1991; Rigol, 1991), (3) definition of standard calculator functions (Rigol, 1991), (4) the need for curriculum changes (Darken, 1991), (5) effects on student learning (Darken, 1991; Dick, 1988; Saxon, 1986), (6) availability to students and classrooms (Reys et al., 1980; Rigol, 1991), (7) grade levels for inclusion (Hembree, 1986; Reys et al., 1980), (8) potential gender differences in their usage (Munger & Loyd, 1989), and (9) lack of required teacher training (Reys et al., 1980). One researcher summarized the issues by stating that, "The effect of calculator use on the acquisition of basic skills has always been the main disagreement..." (Dick, 1988, p. 38). Yet, the other matters on the aforementioned list can not be ignored.

In spite of this list of issues opposing the utilization of calculators for teaching mathematics, support of their use has remained strong. The National Council of Teachers of Mathematics (NCTM), a professional association of mathematics teachers, educators, and other professionals, "recommends the integration of the calculator into the school mathematics program at all grade levels in class work, homework, and evaluation" (National Council of Teachers of Mathematics, 1987, p. 61). NCTM suggested that using calculators in schools could free large amounts of time students currently utilize practicing computation. They also proposed that this time should be utilized to help students understand the basics of mathematics, develop reasoning and problem solving strategies, and apply mathematical principles. NCTM suggested that students could then concentrate on the problem-solving process rather than rote calculations, experiment with other mathematical ideas, and reduce tedious and boring computation. In February of 1991, NCTM (1991) issued a position statement on "Calculators and the Education of Youth" which is consistent with, and expanded, their earlier published recommendations. However, what percentage of American mathematics teachers does the NCTM represent? In one 1979 survey of 194 math teachers Reys et al. (1980) found that only 13% of the sample belonged to NCTM; so whose voice should be listened to?

The cost of small electronic calculators has decreased and their reliability has increased immensely in recent years. Technology has changed and advanced at exponential rates in modern American society. How should these changes influence American mathematics education? One extensive study of calculator and computer usage in twenty countries suggested that America is falling behind other counties in the integration of technology into the classrooms (Jaji, 1986). Jaji surveyed twenty countries that included 3779 individual schools, 5902 teachers, and 117,698 students. Jaji found that many schools in different countries had policies forbidding the use of calculators in class, however, this was not the general case for the United States. Nonetheless, of the schools in that did allow its usage, America lagged behind the other counties in using calculators as part of the educational process. The United States was among the leaders, though, in countries that utilized computers in mathematics education.

Given the ready access of cheap reliable calculators today, and the still comparatively limited use and availability of computers to individuals and schools, the resolution of technology in the classroom is a pressing issue. This is especially true for America which is a world technology leader yet appears to lack the benefits of its own leadership position. Bitter and Hatfield (1992, p. 200) noted that,

> the failure of schools to exploit calculators in mathematics instruction is puzzling. Calculators have become ubiquitous, but regular classroom use is sporadic.

Coupled with the already growing concerns about the quality of American education, the use of calculators in mathematics classes today is an issue that can no longer be ignored.

Review of Literature

The review of literature below focused on secondary mathematics education, although the research also drew upon some pre and post secondary studies where the information was applicable. Secondary mathematics education in New York state, where the Mid-Hudson Valley is located, includes all math courses taught in grades seven through twelve. Additionally, the operational definition of calculator has been limited to include hand held, nonprogrammable, scientific calculators only. It did not include graphing calculators, or any types of micro-computers. This review examined the issues and findings of various studies regarding the usage of hand held calculators in secondary education today.

In spite of the National Council of Teachers of Mathematics support of calculators, opposition to the usage of hand held calculators in American education appears to remain high. During the 1980's fewer than 20% of all elementary school teachers utilized calculators, and fewer than 36% of all secondary school teachers utilized them in classrooms (Hembree, 1986; Hembree & Dessart; 1986; Suydam, 1982). These percentages seem to have changed very little according to a recent study conducted by Loyd (1991). Additionally, 43% of all college math instructors surveyed opposed their use in class, while only 40% supported it (Chambers, 1989). During this same time

period, the research suggested that 68% of all K-12 students had access for use to at least one calculator in their home (Reys et al., 1980).

As previously noted in the host of issues cited above, many American educational leaders have not provided directional policies on the use of calculators in their school systems. Jaji (1986) reported that over 50% of the 307 U.S. schools surveyed lacked a calculator usage policy. As noted by Terranova (1990), teachers are looking for some direction on the use of calculators in their classrooms. Darken (1991) suggested that the use of calculators in the classroom must be supervised and "curricular reform emphasizing greater understanding and increased use of technology has become a major topic of discussion at mathematics conferences at all levels" (p. 8). Mathematics curriculum reform to integrate the use of calculators and technology into the classroom has been advocated by numerous educators (e.g., Campbell & Stewart, 1991; Darken, 1991; Kysh, 1991; National Council of Teachers of Mathematics, 1987; Rigol, 1991; Templeton & Paden, 1991). Along with the issues of policy and curriculum, a definition of the standard set of acceptable minimum and maximum calculator functions should be developed.

Some educators argued that manual practice is the only way to learn mathematics and the use of calculators undermines student learning (Saxon, 1986). Other educators reported that they need training in the usage of calculators before they can utilize them in their classroom (Reys et al., 1980; Terranova, 1990). In a study of 348 elementary school teachers and principals from western New York State, one researcher concluded that teachers and principals believe calculators should be used in math classes today, however, in-service training is required before this will occur (Terranova, 1990). Additionally, curricula appeared to need modification and directional policies needed to be established to assist this implementation.

With regards to testing with calculators, the literature was full of information on this topic. Chambers (1989) reported that 60% of all K-12 standardized mathematics tests are commercially developed and another 11% are designed by state agencies. He suggested that commercially developed standardized achievement tests need to be redesigned to include calculator usage while local tests should assume students have access to calculators. Kenelly (1990) noted that

standardized tests are an important means of comparing students achievement across various populations, and use of calculators should be allowed during the tests. He further stated that an important part of any test, in addition to the use of calculators, is also deciding when to use the calculator. Kenelly suggested that some problems are computed much faster by the human mind while others just do not require the calculator's use. In concert with this observation, the National Center for Education Statistics (1992) found that within a sample population of twelfth grade students, 70% of the sample failed to utilize the calculator's functions properly at least 85% of the time tested. Harvey (1991) proposed that future tests may require "two environments"; portions that allow the use of calculators and portions that do not. He related this testing decision back to how the content was taught to the students.

In a survey conducted by the Educational Testing Service for the College Board to examine the status of calculator usage among college-bound students, Maroney (1992) reported that "in general, the response to the questionnaire indicates that most educators favor the use of a calculator on the SAT" (p. 6). Maroney also found that the calculator secondary educators thought "to be most appropriate for use with the SAT was a nonprogrammable scientific calculator" (1992, p. 4). Rigol (1991) noted that college SAT's will be modified to allow the use of calculators on tests starting in 1994. Rigol commented that while this change in testing policy has been implemented, the College Board still had two concerns with the use of calculators. First, not all students might have been taught how to utilize calculators, hence they may be at a slight disadvantage. Secondly, not all students may have calculators. Nonetheless, future college SAT's will be changed to allow the use of calculators by the test takers.

Long, Reys, and Osterlind (1989) evaluated the results of the Missouri Mastery and Achievement Tests (MMAT) administered to eighth and tenth grade students who were allowed to utilize calculators on these tests for the first time in 1987. There was little guidance in the use of calculators and their use was optional. The MMAT was administered to approximately 240,000 students and a sample of over 5000 participants from each grade grouping was studied. Approximately 56% of the tenth graders used a calculator, while 45% of the eighth graders did. In

general, students in both grade levels who utilized calculators performed significantly better ($p < 0.01$) than those students who did not. Long et al. noted that "as the complexity of the test items increased, the difference between the performance of the calculator and noncalculator groups diminished" (p. 320). This result suggested that the use of calculators in secondary math truly aids just rote computation as opposed to assisting student problem solving skills. Also based upon the results of this test, these researchers believed that use of calculators on standardized tests is manageable, and permitting the use of calculators on examinations would lead to changes in classroom curriculum.

In a study of 160 high school students to determine if there were performance distinctions on different item types of standardized math tests, Loyd (1991) found that overall, students who were permitted to use calculators performed significantly better than those who were not permitted to use calculators. Loyd attributed these differences to reduced computation errors, and potentially greater confidence and a better test taking attitude by the calculator users. The study also found that effects of calculator usage differed by the item types included on standardized tests. By design, the researchers utilized four different test item types. Type I involved more difficult levels of computation as well as estimation problems where the use of a calculator might benefit students. Type II items included calculations that could easily be done without the use of a calculator. Type III items did not involve any calculations, while Type IV items were modeled after problems that would make it more difficult to utilize a calculator. In general, calculator users performed significantly better than noncalculator users on Type I test items. On Type II and III test items, calculator users performed better but their results were not statistically significant. On Type IV test items, there was no significance difference in performance by either group of students.

In a analogous study on calculator effects on item types conducted by Cohen and Kim (1992), these researchers reached similar [illegible]sions. That is, items "that were easier when a calculator was used required either simple c[illegible]ions or use of a function key" (p. 303). Whereas, "items that were more difficult required knowledge of a procedure either with or without additional computation" (p. 303). Interpretation of these results might lead one to the conclusion that if a

student did not know how to perform a mathematical operation, the use of a calculator would be of little assistance.

In a separate study of 60 high school math students, Munger and Loyd (1989) found no significant differences between male and female gender when using calculators to solve math problems. However, they found significant differences between students who utilized technology and those that did not. Calculator users, with positive attitudes towards technology, performed significantly better on tests than those students without calculators.

These conclusions were very similar to those reached by Szetela and Super (1987) who studied 24 seventh grade classes regarding math problem-solving strategies, gender differences, and use of calculators. They found that students who utilized calculators scored significantly higher on tests than non-calculator users, and there was no loss of basic math skills by the calculator users. Additionally, calculator users had better attitudes towards math and problem solving. Szetela and Super also found that no significant differences in calculator performance based upon gender differences existed. In a separate prior study by Szetela (1982) of elementary and middle school students, the researcher found that the students utilizing calculators performed significantly higher than those students who did not have calculators. Szetela also concluded that there was no loss of basic skills after using calculators for math instruction.

In general, the literature suggested that the use of calculators in mathematics instruction had positive benefits on student learning including the following: (1) facilitated better problem solving (Campbell & Stewart, 1993; Suydam, 1982, 1987; Templeton & Paden, 1991; Yvon, 1987), (2) improved student attitudes towards math (Hembree, 1986; Hembree & Dessart, 1986; Templeton & Paden, 1991; Yvon, 1987), (3) improved overall math skills by allowing the student to focus on the process and experiment rather than be concerned with tedious computations (Yvon, 1987), (4) resulted in higher achievement scores on tests (Hembree, 1986; Hembree & Dessart, 1986; Loyd, 1991; Munger & Loyd, 1989; Suydam, 1982, 1987; Szetela, 1982; Szetela & Super, 1987), (5) provided for improved student motivation and confidence (Campbell & Stewart, 1993; Dessart & Suydam, 1983; Finley, 1992) , and (6) allowed students to consider more complex tasks

(Campbell & Stewart, 1993). In addition, Finley (1992) found that students "who are exposed to these calculator experiences find going from the concrete to the abstract a much easier transition" (p. 199).

With reference to specific mathematics applications, Leitzel (1989) identified four research issues in the teaching of algebra, a cornerstone secondary education mathematics course; these included: (1) consideration of content and approach, (2) new computational tools, (3) the importance of numerical methods, and (4) the concept of function. Regarding computational tools, Leitzel (p. 26) noted

> The availability of calculators and computers permits a numerical approach to algebra quite different from the formal axiomatic approach of recent years. ... for the present it is the hand-held calculator that has the potential for greatest impact on teaching algebra and other mathematics. The low cost of sophisticated scientific calculators means that every student, from middle grades up, can be assumed to have a calculator. Computation can therefore be used intentionally to introduce key concepts of algebra.

Leitzel added that "the advantage of having calculators in algebra courses is that students can start with problems and calculators, rather than starting with axioms" (pp. 26-27), and that "students can solve problems without resorting to formulas and mechanical processes" (p. 27).

While some of this support was drawn upon in the form of anecdotal evidence, several studies substantiating these findings were previously cited. Additionally, in a "state-of-the-art" review conducted by Suydam (1982), approximately 150 studies of mathematics and calculators were reviewed and summarized. The results supported the positive benefits of calculator use in mathematics previously noted. Suydam ascertained that "if the child does not know how to solve a problem, it does not make much difference whether calculators are use or not" (p. 3).

In an extensive meta-analysis of 79 reports on the effects of calculator use on student achievement and attitude in K-12, Hembree and Dessart (1986) concluded that: (1) student skills were improved through the use of calculators and there was no loss of basic skills, (2) only in the 4th grade did calculator use appear to hinder student development, (3) students tested with calculators scored much higher achievement, and (4) students using calculators had better attitudes

towards math and better self-concepts about math. In a recent updated review of the usage of calculators in mathematics education. Hembree and Dessart (1992, p. 30) concluded,

> The preponderance of research evidence supports the fact that calculator use for instruction and testing enhances learning and the performance of arithmetical concepts and skills, problem solving, and attitudes of students.

They further suggested that, "to deny the use of calculators for both instruction and testing is an antiquated policy that should be changed" (p. 30).

In a study of middle to low socio-economic status (SES) students, Templeton and Paden (1991) found significant achievement gains from calculator users. They also detected better student and parent attitudes towards mathematics and technology changes in the classroom. Finally, in the *Curriculum and Evaluation Standards for School Mathematics*, the National Council of Teachers of Mathematics (1989) recommended that appropriate calculators be available to all students at all times (p. 8). NCTM also advocated that the students' understanding of mathematics should equip them to know when and how to utilize various technology for problem solving. NCTM recommended that "students should have a balanced approach to calculation, be able to choose appropriate procedures, find answers, and judge the validity of those answers" (p. 8). The *Standards* suggested that the use of "appropriate scientific calculators" (p. 126) should receive increased attention in mathematics instruction. NCTM (1989, p. 8) also noted the following:

> Contrary to the fears of many, the availability of calculators and computers has expanded students' capability of performing calculations. <u>There is no evidence to suggest that the availability of calculators makes students dependent on them for simple calculations</u> (italics added).

Yet, as noted previously, usage of the calculators in mathematics instruction appears to remain low in American classrooms today. The National Center for Education Statistics (1992) reported that National Assessment of Educational Progress (NAEP) "data reveal minimal use of computers and calculators in mathematics instruction" (p. 4) and "that NCTM's recommendations have not been implemented" (p. 3). Similar conclusions were reached in a two year study of 580 seventh

and eighth graders; Bitter and Hatfield (1993) found that although "appropriate use of the calculator has the potential to positively affect mathematics instruction, its use is still controversial" (p. 78). The study was a joint venture among Arizona school district administrators and teachers, Texas Instruments, and Arizona State University to assess attitudes toward calculator usage. Bitter and Hatfield (1993) reported that "although student and parent perceptions appear to be quite positive, participating teachers differed widely in the degree to which they integrated the calculator as suggested by NCTM" (p. 78). The researchers found that integration of the calculator into mathematics could positively influence student performance yet teachers require in-service training to effectively bring about positive results. The teacher training should address methods of integrating calculator usage and the value of doing so. Bitter and Hatfield also suggested that additional research on how to modify mathematics curriculum and integrate calculators usage should be undertaken.

Still, these noted recommendations are not new. In 1983 Dessart and Suydam suggested that "the calculator is a most useful tool for calculational purposes, but its potential value may never be realized if the curriculum does not lend itself to the incorporation of the calculator" (1983, p. 43). Reys and Reys (1987) reported that school policies on calculator usage should be developed, math curricula updated, and standardized testing changed to allow the use of calculators. They called for additional research that "integrates the calculator in meaningful and useful ways" (Reys & Reys, 1987, p. 14). As Terranova (1990) suggested, teachers and educational leaders are looking for direction on this issue.

Hembree and Dessart (1986) noted that future research on this topic should be directed towards pedagogical uses and they suggested several potential topics including: procedures for calculator usage and the effects upon curriculum changes. Hembree (1986) stated that the "question of how the device (calculator) can best be used for effective instruction demands research attention, a need recognized in previous reports" (p. 21). Recently Hembree and Dessart reaffirmed these needs when they concluded that "further research should dwell on the best ways to implement and integrate the calculator into the mathematics curriculum" (1992, p. 30) and that

"the integration of the calculator into the curriculum where it plays a central role in the learning process is a worthy goal for the research of the 1990's" (Hembree & Dessart, 1992, p. 31). Additionally, they stated that "there have been no empirical studies on how to integrate the calculator directly into the learning process" (Hembree & Dessart, 1992, p. 30). Likewise, Campbell and Stewart (1993) noted that "there has not been research on the effects of a curriculum that totally integrates the calculator nor has there been research on how children construct mathematical understandings within such a curriculum" (p. 262).

Based upon the literature previously cited, the question does not appear to be 'should' calculators be utilized in teaching mathematics but rather it should focus on 'why' calculators aren't being used more readily and 'how' to integrate the usage of calculators into mathematics in the secondary education environment. As Dick (1998) noted, calculators need to be seen as a valuable tool, "a powerful problem-solving resource that allows students to investigate patterns and relationships without being overly burdened with tedious paper-and-pencil computations" (p. 39). Darken (1991) stated that our mathematics educational focus is wrong. He suggested that instructors do not sufficiently focus on problem solving strategies and basic math conceptual understandings; the use of the calculator should assist a change in this focus.

In spite of research that has supported the positive benefits of calculator usage in secondary mathematics, controversy and research questions have still remained. Hence, the opportunity existed, and the need was present, to study 'why' high school educators had not implemented calculator usage into the mathematics environment in a structured fashion and 'how' this could have been done more effectively. The remainder of this study focused on the question of 'why' the use of calculators as learning tools has remained low in secondary mathematics instruction.

Hypotheses

Research has suggested that use of calculators in secondary education mathematics improves student learning. However, questions remained on why the same literature has also implied that teachers in the profession of secondary education have failed to exploit calculators in the

classrooms in an integrated fashion as learning tools. This study proposed four potential reasons for the failure of secondary education mathematics teachers to utilize calculators in the classroom. The four suggested possible causes included the following: (1) the lack of defined school district policies which set a direction on calculator usage, (2) the lack of availability of scientific calculators to all students in the secondary education system, (3) the lack of in-service teacher training on calculator usage, and (4) a shared lack of support by secondary education teachers themselves.

The hypotheses of this study were as follows. First, the failure of school districts to have defined calculator usage policies, and/or guidelines, has resulted in few district mathematics teachers fully integrating the use of calculators into course curricula during routine instruction. Second, the lack of availability of scientific calculators to all students in secondary education mathematics courses has resulted in few district mathematics teachers fully integrating the use of calculators into course curricula. Third, the lack of available district in-service teacher training on the use of scientific calculators has resulted in few district mathematics teachers fully integrating the use of calculators into course curricula. Fourth, and finally, the lack of shared support by secondary education mathematics teachers themselves, for the use of calculators in routine instruction, has resulted in few district mathematics teachers fully integrating the use of calculators into their own course curricula.

The literature cited, and prior research has suggested that calculators used for teaching mathematics would improve student performance as measured on achievement tests, and in other tangible ways. Yet, these same references have acknowledged a failure on the part of mathematics teachers to utilize calculators in the classroom as learning tools. Therefore, it would appear that there are inhibitors which have prevented secondary education mathematics teachers from adopting and implementing the National Council of Teachers of Mathematics' calculator usage recommendations. The goal of this study was to identify and understand what some of the major inhibitors might have been so that potentially they could be addressed at some future time.

Method

Subjects

A sample of secondary education principals and mathematics teachers from the Mid-Hudson Valley region, within approximately a fifty mile radius of Marist College in Poughkeepsie, New York, were questioned via a survey. This target sample of subjects was chosen due to their close proximity to Marist College, and because the Mid-Hudson Valley region in upstate New York was a geographic area of particular interest to this researcher. The sample included both high school principals/administrators and mathematics teachers from larger urban schools, high schools with a student population of 800 or more in grades nine through twelve, and smaller rural schools with less than 800 students in their senior high school classes. Altogether forty-seven school district superintendents were contacted requesting permission to survey the district high school principal and one mathematics teachers.

Thirty-four school districts, or 72.3% of those contacted, responded back to the preliminary mailing. Approval to proceed with the survey was secured from thirty-two school district superintendents. Of the two other responses, one responder indicated that the school district did not service a full senior high school structure; certain specific grades were subcontracted to another local school district for instruction. The other responder requested that permission to conduct the survey within the school district be obtained from a different source. Due to time delay in this response, and time constraints on the overall research project, an individual follow-up letter that requested approval from this school district was not sent.

Once given superintendent approval to conduct this survey in each of thirty-two school districts, the available sample population comprised of sixty-four possible participants. This included thirty-two high school principals and thirty-two secondary education mathematics teachers. Forty-three of sixty-four potential surveys were returned; that is, 67.2% of the available sample population returned surveys. Responders included twenty-five mathematics teachers and

eighteen high school principals or administrators. Note, the titles high school principal and administrator are used interchangeable in the remainder of this study.

The school districts surveyed exhibited different organizational structures at the district high school level. Some districts had a middle school, grades six through eight, and a senior high school, grades nine through twelve. Other districts combined grades seven through twelve at the high school level and had no middle school. Therefore, to compare the various school districts surveyed, the classification of district size was based solely on the high school grades of nine through twelve. Sixteen surveys were returned from school districts with 800 or more students in their senior high school classes while twenty-six surveys were from school districts with 799 or less students. One returned survey did not contain information regarding the size of the school district student population. The number of students in grades nine through twelve of the participating school districts ranged from approximately 200 to 2000 pupils.

Distribution of Survey Participants:

	Rural	Urban	Unknown	Total
	n	n	n	n
Teachers	15	9	1	25
Administrators	11	7	0	18
Total	26	16	1	43

Instruments

To examine the previously defined four hypotheses, a calculator usage survey was designed and distributed to local high school administrators and secondary education mathematics teachers. The National Council of Teachers of Mathematics's (February, 1991) position statement on calculator usage in the classroom was used to help define questions on the calculator survey. Participants were requested to supply information on job description, student population, the percentage of students having scientific calculators, the percentage of district mathematics that integrated calculators into their curricula, the percentage of district math teachers that support the use of

calculators during instruction, calculator usage during math tests, in-service training provided, anecdotal input on educational benefits and problems resulting from calculator usage, district calculator policies, and their awareness of NCTM's calculator recommendations. Refer to Appendix A for a copy of the calculator survey.

The survey questionnaire utilized a mixture of direct questioning techniques and Likert scales to solicit data for this study. Direct questions petitioned information about the responder's job title; i.e., administrator or teacher. This was done to investigate if differences might have existed between the survey responses of administrators and math teachers, and to improve the chances of getting at least one response back from each school district surveyed. The student population information, of grades nine through twelve, was requested to categorized the school as urban or rural so that responses could also be examined based upon school district size. A student population of 800 was chosen as a break point between urban and rural school districts prior to any data analysis. Eight hundred was chosen as the break point based upon this researcher's conceptual view of what consisted an urban versus a rural school district with input from several local high school administrators.

Likert scales were utilized to collect data on the percentage of district students that own scientific calculators, the percentage of district classes that had integrated calculator usage into classroom curricula, and the percentage of mathematics teachers that support the use of calculators as part of normal classroom instruction. The percentage of students owning calculators and the percentage of teachers supporting calculator usage, as well as input on in-service training and school district calculator policies, were viewed as this study's independent data variables. The percentage of secondary mathematics classes which had integrated calculator usage into the course curriculum was viewed as the dependent variable measured to test the aforementioned hypotheses.

Additionally, anecdotal data on possible educational benefits derived from student calculator usage, and problems perceived in teaching with calculators was solicited. This information was requested in an effort to identify other potential benefits and problems which might have been previously unconsidered in prior research on this topic noted in the literature review; and to

compare results of this study with prior research findings. Data was also collected on calculator usage during math tests and NCTM calculator recommendation awareness and standards utilization. This information was requested to estimate the potential impact and employment of NCTM's calculator recommendations.

Materials

Materials required for this study included a copy of the NCTM's position statement on calculator usage in the classroom (National Council of Teachers of Mathematics, February, 1991) and envelopes to conduct the survey via U.S. mail. NCTM's (February, 1991) calculator recommendations were utilized to help define questions on the calculator survey. Two different size envelopes, 6 1/2" by 9 1/2" clasp envelopes to mail out study materials and standard white business envelopes to receive survey replies back, were used to conduct the survey. Additionally, postage for the mailings was required. The cost to conduct this survey was approximately two hundred dollars which was underwritten by this researcher.

Procedure

The names and addresses of superintendents and principals for school districts in Dutchess, Putnam, and Ulster counties, as well as districts within a fifty mile radius of Marist College in portions of Columbia, Greene, Orange, and Westchester counties, were identified in the 1993-94 edition of the *Directory of Public Schools and Administrators in New York State* reference. The initial mailing consisted of a letter that sought the approval of the school district's superintendent to conduct the survey within the district. This was sent to the superintendents of all districts to be surveyed along with: (1) a sample letter addressed to the high school principal, and (2) a copy of the calculator survey. Two weeks following the initial superintendent mailing, one follow-up letter was sent to each district superintendent which had not previously responded to the original request.

Upon individual receipt of each superintendent's permission to conduct the survey in that school district, a letter addressed to high school principals that introduced the survey was then sent

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to the district high school principal along with two copies of the survey and a copy of the superintendent's approval. The letter provided instructions on how to proceed with the survey at the high school level. The survey was conducted anonymously through the mail and participants were informed that they could skip any question that they chose not to respond too. Ten days after the initial letter was sent to individual district principals, one follow-up letter was sent encouraging the district's voluntary participation. Self-addressed stamped envelopes were included so that surveys could be returned directly back to this researcher. Refer to Appendices B for copies of all letters sent to each party involved.

Results

Data Analysis

Survey participants were informed that they could disregard any question that they chose not to respond too; some responders did skip at least one question. However, 90.7% of all participants responded to at least portions of ten or more of the twelve questions asked. The data received was first examined on a cumulative basis without regard to job description and/or school district size. The information was then evaluated to determine if any differences in the results could be attributed to the educator's job responsibilities; that is, district administrators versus mathematics teachers. Finally, the input was examined based upon the size of the school district; that is, results of school districts with 800 or more students in their senior high school classes were compared to those districts with 799 or less students. There were no control groups involved in this study.

Pearson correlations and independent t-tests were utilized to examine the four previously stated hypotheses. Without consideration of possible cause and effect relationships, Pearson correlations were used to determine if the estimated percentage of district secondary mathematics students having calculators, Question #3, and the estimated percentage of all district secondary mathematics teachers that supported the use of calculators, Question #5, were correlated to the estimated percentage of district secondary mathematics classes which had integrated calculator usage into

course curricula, Question #4. The Pearson correlations established the degree to which these percentages were linearly related.

Independent t-tests, at the 0.05 level of significance, were run by blocking the information on Questions #3 and #5 into two sample groups per question. The first group represented all of the survey participants who responded '1' or '2' for Questions #3 and #5 respectively. The second group represented all of the survey participants who responded '4' or '5' for Questions #3 and #5 respectively. The mean responses of Question #4 for both sample groups, for each of Questions #3 and #5, were compared respectively utilizing independent t-tests.

Additionally, independent t-tests utilizing Question #4 as the dependent variable, and the responses from Questions #6 (teacher support services), #8 (in-service training), #11 (district calculator policies), and #12 (awareness of NCTM calculator recommendations) as the independent variables, were run utilizing the cumulative data responses. Two sample groups, per each of the four noted questions, were created. The sample groups consisted of all survey participants who responded 'yes' on each individual question compared to all survey participants who responded 'no'. Independent t-tests, comparing the mean responses for Question #4 of both sample groups for each of the four questions, were run at the 0.05 level of significance.

Likewise, several of the above described Pearson correlations and independent t-tests for the cumulative data were run again with consideration given to data based upon job description and school district size. This was done to determine if differences in the mean responses of administrators and teachers, and the survey responses of participants from school districts with 800 or more students compared to those districts with 799 or less students, could be attributed to statistically significant differences on survey responses to Question #4.

In addition to the aforementioned tests of the study's hypotheses, chi-square distribution tables were calculated for the 'yes' and 'no' responses to Questions #6 (teacher support services), #7 (math tests), #8 (in-service training), #11 (district calculator policies), and #12 (awareness and utilization of NCTM calculator recommendations) for the survey responses of teachers and administrators, as well as, rural and urban school districts. This was done to assess the amount of

variance that existed in the survey responses to these questions, and to determine if there were statistically significant differences that could be attributed to job description and/or school district size of survey participants. The significance level of these tests was 0.05. Finally, where anecdotal data was requested, it was summarized by question and examined to determine what common themes could be identified. The results of the study were as follows.

Hypotheses

The Pearson correlations yielded few statistically significant relationships at the 0.05 level of significance although several comparisons were statistically interesting at the 0.10 significance level. For example, when only the survey responses of the participating teachers were examined, the data suggested a somewhat correlated relationship between the integration of calculators into routine instruction (Question #4) and district teacher support for the use of calculators (Question #5). While not significant, the Pearson correlation coefficient was 0.28 with a 0.09 level of significance. Conversely, when only the survey responses of administrators were utilized, the data suggested a somewhat correlated relationship between the integration of calculators into routine instruction (Question #4) and the percentage of district teachers who supported the use of calculators (Question #5), as well as, between the integration of calculators into routine instruction (Question #4) and the percentage of all district mathematics students who had calculators (Question #3). While not significant, the Pearson correlation coefficients were 0.34, with a significance level of 0.09, and 0.29, with a significance level of 0.14, respectively.

When the cumulative responses were examined without regard with to job classification, district teacher support of the use for calculators (Question #5) was statistically correlated to the integration of calculators into routine instruction (Question #4). This comparison exhibited a Pearson correlation coefficient of 0.30 and a significance level of 0.03. However, the availability of calculators to district students (Question #3) compared to the integration of calculators into routine instruction (Question #4) for the cumulative survey responses displayed a Pearson correlation coefficient of 0.17 and significance level of 0.15.

When the same survey questions were examined based solely upon the size of the school district using Pearson correlations and independent t-tests, they were not statistically significant. Nevertheless, data from the survey participants of urban school districts suggested a somewhat correlated relationship between the integration of calculators into routine instruction (Question #4) and district teacher support of the use of calculators (Question #5). While not significant, the Pearson correlation coefficient was 0.41 with a significance level of 0.06.

Independent t-tests for Questions #6 (teacher support services), #8 (in-service training), #11 (district calculator policies), and #12 (awareness of NCTM calculator recommendations) utilizing all three levels of data collected failed to yield any statistically significant results at the 0.05 level of significance. However, when Question #11 (district calculator policies) was tested utilizing only the responses from teachers, the results were statistically interesting at a 0.10 level of significance. Independent t-tests of only the teachers' survey data resulted in a significance level of 0.09 for district calculator policies, Question #11.

Hence, the survey data was examined based upon the cumulative responses of all the participants, the participant's job description, and the school district size utilizing Pearson correlations and independent t-tests. In summation, with the exception of the Pearson correlation of the cumulative survey responses for Question #5, teacher support of calculators, compared to Question #4, integration of calculator usage into mathematics curricula, none of the Pearson correlations yielded statistically significant results at the 0.05 level of significance. Also, none of the independent t-tests yielded statistically significant results at the 0.05 level of significance. Refer to Appendix C for a summary of the Pearson correlations and independent t-test results.

Descriptive Statistics

When the distribution of the cumulative responses for Questions #3, #4, and #5 was examined, the following patterns were observed. Of the total survey participants, 70.7% of all the responders estimated that less than 40% of all district secondary mathematics students had a scientific calculator; while 7.3% of the participants estimated 60%, or more, of the students had scientific

calculators. Of all the survey participants, 46.4% estimated that less than 40% of all district mathematics classes had integrated calculator usage into the course curricula; while 41.5% of all survey participants estimated that 60%, or more, of the classes had integrated usage of the scientific calculator into course curricula. Fifty-seven percent of all the survey participants estimated that 60%, or more, of all district mathematics teachers supported the use of scientific calculators as part of normal instruction; while 28.5% of the participants estimated that 39%, or less, supported the use of calculators.

When this same data was examined based solely upon job description and/or school district size, results were similar to the cumulative results reported above with one exception. The administrators were more positive in their estimates about the percent of teachers who supported the usage of calculators than the teachers themselves. Sixty-five percent of the administrators estimated that 60%, or more, of the teachers supported the use of calculators in mathematics curricula compared to 52% of the teachers who responded the same. Refer to Appendices D for a complete distribution of responses to Questions #3, #4, and #5.

When the 'yes'/'no' distributions of the cumulative responses for Questions #6 (teacher support services), #7 (math tests), #8 (in-service training), #11 (district calculator policies), and #12 (awareness and utilization of NCTM calculator recommendations) were evaluated, the following percentages were observed. Of the total survey responses, 77.5% of all the participants reported that teacher support services existed. With reference to using calculators on math tests, 85.4% of all participants reported that calculators were allowed during tests. Seventy-one percent of the cumulative survey responses indicated that no in-service teacher training on calculator usage was available, and 81% of all participants reported that the school district had no calculator usage policy. There was insufficient data to have reached any conclusion with regards to district calculator policies being available in writing and followed by districts teachers. (Seventy-one percent of all the responders disregarded this question and those participants who answered it were split equally in their responses.) Conversely, 88.1% of all survey participants reported an

awareness of NCTM's calculator recommendations, while 57.1% of all responses indicated that the participants utilized these recommendations.

When this same data was examined based solely upon job description and/or school district size, results were very similar to the cumulative findings reported above. However, there were some differences in responses between the administrators and teachers, and between the rural and urban school districts. Approximately ninety-one percent of the teachers estimated that calculators were allowed on tests while 76.5% of the administrators reported the same. Forty-one percent of the administrators estimated that in-service teacher training was available compared to 20% of the teachers who estimated likewise. Additionally, 92% of the teachers reported an awareness of NCTM calculator recommendations compared to 82.4% of the administrators reporting the same. Yet, reported utilization of the NCTM recommendations by teachers and administrators was approximately the same.

Examining the same data with reference to school district size, 43.8% of the participants from urban school districts reported that in-service teacher training was available while only 16% of the rural school participants reported the same. Regarding NCTM calculator recommendations, 96% of the rural school participants reported an awareness to these compared to 81.3% of urban school district participants who did the same. Again, reported utilization of NCTM's calculator recommendations was approximately equal regardless of the school district size. Refer to Appendix E for a summary of these results.

Participant Response Variance

The chi-square analysis of survey Questions #6 (teacher support services), #7 (math tests), #8 (in-service training), #11 (district calculator policies), and #12 (awareness and utilization of NCTM calculator recommendations) based upon job description failed to show any statistically significant results at the 0.05 level of significance. However, when the responses for Question #8 (in-service training) for the teachers was compared to the responses of the administrators utilizing this

statistically measure, results were statistically interesting at the 0.10 level of significance. The chi-square test yielded a probability of 0.14.

The chi-square analysis of survey Questions #6 (teacher support services), #7 (math tests), #8 (in-service training), #11 (district calculator policies), and #12 (awareness and utilization of NCTM calculator recommendations) based upon school district size revealed both statistically significant results, at the 0.05 level of significance, and statistically interesting results at the 0.10 level of significance. Survey responses for Question #8 (in-service training) based upon a chi-square analysis of data from rural and urban school districts was statistically significant with a 0.05 level of confidence. Additionally, survey responses for Question #12 (awareness of NCTM calculator recommendations) were statistically interesting at the 0.10 level of significance with a 0.12 probability. Refer to Appendix F for a summary of the chi-square distributions.

Anecdotal Survey Input

The calculator support most lacking reported on Question #6 was overhead projectors and/or audio visual equipment. This appeared on five surveys, or 11.6% of all survey responses. The second most reported item was the lack of consultants which was noted on 3 surveys (7%). Also flagged as lacking were: scientific calculator themes for instruction, "everything", "little support available", more calculators, and "specific support for scientific calculators (italics added)". Each of these items was mentioned once. As noted above, 77.5% of all survey participants reported that calculator services existed, and most survey responders to this question failed to provide input on what services, if any, that they felt were lacking.

The most frequently identified educational benefit reported on Question #9 was improved problem solving and teaching of mathematical concepts. This perceived benefit was reported by 22 survey participants, or 51.2% of all responses. Closely following this response was reduced time for mathematical computations thus allowing more time for problem solving and learning. This was accounted for by 19 survey participants (44.2% of all responses). Following these were: the ability to teach more complex problems (30.2%), students learning with technology (23.3%),

and improved student attitudes towards mathematics (16.3%). Also reported were: improved accuracy, increased exploration, and improved checking and estimation. Refer to Appendix G for a list of responses to Question #9.

The most frequently identified educational problem resulting from using calculators, Question #10, was the cost of calculators themselves, both to students and the school, and equity in learning. This problem was reported by nine survey participants, or 20.9% of all responses. Two reported problems were tied for second by seven survey responders, or 16.3% of all participants. These were: training and encouragement of school staff, and the need for appropriate standards on calculator usage and functions. Several perceived problems were equally identified including: degradation of student math skills, in-service teacher training on the use of calculators, and public acceptance of the use of calculators in schools. All of these problems were identified on six responses, or 14.0% of the surveys. The major difference noted between staff training and in-service training was the encouragement of staff to utilize calculators and the ability to visit other schools that have successfully implemented calculators, as opposed to purely receiving in-service training on specific calculator functions. Other reported problems included: the lack of supporting math text-books, teaching students when to utilize calculators, and curriculum revisions to support the uses of calculators. Refer to Appendix G for a list of responses to Question #10.

Discussion

Hypotheses

Based upon the results of the Pearson correlation tests and independent t-tests, the following hypotheses were not supported. First, the failure of school districts to have defined calculator usage policies, and/or guidelines, resulting in few district mathematics teachers fully integrating the use of calculators into course curricula during routine instruction was not supported. Hence, the null hypothesis that the lack of defined school district calculator usage policies, and/or guidelines, had not resulted in secondary education mathematics teachers to fail at fully integrating calculators into course curricula should not be rejected.

Second, the lack of availability of scientific calculators to all students in secondary education mathematics courses resulting in few district mathematics teachers fully integrating the use of calculators into course curricula was not supported. Consequently, the null hypothesis that the lack of the availability of calculators to mathematics students had not caused secondary education mathematics teachers to fail to integrate calculator usage into course curricula should not be rejected.

Third, the lack of available district in-service teacher training on the use of scientific calculators resulting in few district mathematics teachers fully integrating the use of calculators into course curricula was not supported. Therefore, the null hypothesis that the lack of district in-service calculator training had not resulted in secondary education mathematics teachers to fail at fully integrating calculators into course curricula should not be rejected.

The fourth hypothesis, the lack of shared support by secondary education mathematics teachers for the use of calculators in routine instruction resulting in few mathematics teachers fully integrating the use of calculators into their own course curricula had mixed statistical results. The Pearson correlation was statistically significant at the 0.05 level of significance while the independent t-test was not. The reader is left to draw his/her own conclusions regarding this hypothesis but additional comments on this subject are provided below.

Significance of Study

Existing research has demonstrated that student learning can be improved where calculators are used during the instruction of mathematics. This same research also has indicated that problems exist regarding the integration of calculators into existing mathematics curricula. While results of this study failed to statistically support all of the previously defined hypotheses, the significance of the present study was supported by prior calculator research noted in the literature review. Certain problems in American education can be attributed to the instructional approaches utilized in pedagogy; secondary mathematics is no exception. Some of America's educational problems may have resulted from not properly utilizing our own technology as highlighted by Jaji's (1986) work.

As already noted, the use of technology in American classrooms today continues to be a significant issue facing our educational institutions. While not statistically supported by the results of this study, other problems might result from a lack of policy, direction, or training as was cited by prior researchers above. Whatever the reasons might be, existing research has substantiated the need to investigate why the use of calculators as learning tools in mathematics curricula has not been more successful so that the inhibitors can be addressed.

Due to recent changes in New York State's educational philosophy regarding the use of calculators in the classroom, the defined goal of the present study has taken on even greater significance. In a September 1990 letter from the New York State Education Department (Merrick, 1990, p. 1) to all state school district superintendents, the Education Department recommended the following:

> Calculator usage has been suggested in all state mathematics syllabi developed since 1980. Recent national and state reports have endorsed the sue of the calculator in all mathematics curriculum and assessment. Therefore, the State Education Department:
>
> 1. recommends that all schools teach the use of the calculator as a viable mathematical tool throughout their K-12 mathematics program (italics added) beginning with the 1991-92 school year. All students grade 6 and above should be instructed in the proper use of the calculator so that they will be able to operate them competently on their own.

The New York State Education Department supported this position in the K-12 classroom environment based upon the following national and regional reports: Everyone Counts, a Report to the National on the Future of Mathematics Education by the National Research Council; Reshaping School Mathematics by the Mathematical Sciences Education Board of the National Research Council; a National Council of Supervisors of Mathematics (NCSM) Position Paper; a National Council of Teachers of Mathematics (NCTM) Position Statement on Calculators; and an Association of Mathematics Teachers of New York State (AMTNYS) Position Statement on Calculators in Mathematics Classes.

More recently in a July 1994 memorandum from the Education Department (Lalor, 1994, p. 1) to all New York State school district superintendents, the State Education Department established that:

> Scientific calculators must be made available to all students - including students with disabilities - taking sequential mathematics Regents examinations, courses I, II, and III, beginning in June 1996. Only nonprogrammable and nongraphing scientific calculators may be used.

Based on over twenty three years of experience at a top Fortune 500 company, it is the opinion of this researcher that dictums from above, such as this July 1994 directional statement, generally are not successfully implemented without some detailed implementation plans at the executor's level. Many of the returned surveys contained written comments acknowledging that the New York State Education Department had defined broad state-wide scientific calculator guidelines for the year 1996. However, a t-test analysis of teacher survey responses only, at a 0.10 level of significance, suggested that the lack of district calculator policies resulted in fewer mathematics teachers fully integrating the use of calculators into class curricula. Hence, this researcher would agree with the results of Terranova (1990) that educators are looking for district level policy directional statements to help with the implementation of calculators as learning tools in the classroom. Clearly, based upon the findings of the present study, such policies are not in place today. In fact, 81% of all survey participants reported that their school district had no calculator policies.

Furthermore, as a result of a telephone conversation with a representative of the New York State Education Department, apparent prior concerns with use of scientific calculators in the classroom were based upon the cost of the calculators, and therefore, equity in learning opportunities for all students (E. D. Ostapczuk, personal communication, Oct. 6, 1994). This position was consistent with the results of Question #10 which found that the most frequently identified problem with the use of calculators during classroom instruction was related to their costs and equity in learning. Refer to Appendix G.

However, New York state's recent change in position on this issue might not have gone far enough. Almost all of the literature referenced in the present study cited benefits to all calculator

users at all levels of student ability, not just college bound and/or New York State regents' type students. Thus, while New York's change in direction on this issue was supported by existing research, the state has not yet implemented changes which would be beneficial to all high school students. A representative of the state Education Department reported that further changes, regarding the additional use of calculators in classroom instruction, were under consideration for the future (E. D. Ostapczuk, personal communication, Oct. 6, 1994).

Furthermore, while many of the findings of the present study were not statistically supported, they were nonetheless consistent with conclusions of prior research. Hembree and Dessart (1986), as well as other researchers, reported that fewer than 36% of all secondary education teachers utilize calculators in the classroom. The cumulative responses of this study, Question #4, indicated only 41.5% of all survey participants estimated that 60%, or more, of all district teachers have integrated the use of calculators into classroom instruction. Conversely, 46.4% of all survey participants estimated that 39%, or less, of all district math teachers integrated calculators into classroom instruction. While a slightly different measure of classroom calculator utilization, the findings of the present study appear to be consistent with the work of Hembree and Dessart, less than 50% of the secondary education mathematics teachers in the Mid-Hudson Valley region routinely use calculators in classroom instruction.

Per results of Question #5, 57.1% of all the survey participants estimated that 60%, or more, of all teachers support the use of calculators during routine classroom instruction. This outcome appears consistent with Maroney's (1992) finding that most educators favor the use of calculators. Additionally, Terranova (1990) found that in-service calculator training was lacking as did the results of this study. Results of the present study found that 71.4% of the cumulative survey responses reported that no district in-service calculator teacher training was available.

With regards to teacher support services, Question #6, 77.5% of the survey participants reported that the school district provided teacher calculator support. Of the few survey participants who provided input on the second portion of Question #6, very little information was gathered on what new potential problems might inhibit the use of calculators during classroom instruction.

Furthermore, many of the acknowledged benefits resulting from using calculators in mathematics instruction cited in the review of literature, such as: better problem solving, improved student attitudes towards math, improved math skills, and additional time for more complex tasks, etc., were also identified in the anecdotal data summarized from Question #9. (Refer to Appendix G for a summary of results from Question #9.) Responses to Question #9 appeared consistent with prior research findings and NCTM's position statement on calculator usage in the classroom. Perhaps this could be partially attributed to the high acknowledged awareness and utilization of NCTM's calculator recommendations, Question #12. Almost 88% of all survey participants reported an awareness of NCTM's calculator recommendations, while only 57.1% of all participants reported utilizing these recommendations.

Problems reported by survey participants regarding the use of calculators during classroom instruction (Question #10) were similar in nature to those identified in the literature review. The most prevalent problem reported, the cost of calculator to students and the school, was also shared by the New York State Education Department as previously discussed. Unfortunately, no new problems were identified in the results of the present study which could extend prior research. The inhibitors that might prevent teachers from utilizing calculators during classroom instruction appeared to be the same as those noted in the literature review above and addressed by existing research. Refer to Appendix G for a summary of results from Question #10.

Once again, while not statistically significant some of the findings of this study nonetheless extended the findings of prior research. For example, based upon the cumulative survey responses for Question #4, the estimated district teacher usage of calculators as learning tools appeared to be bimodal. That is, 46.4% of all survey participants estimated that less than 40% of all district mathematics classes had integrated the use of calculators into course curricula. This is compared to 41.5% of the cumulative participants that estimated at least 60%, or more, of the classes had accomplished this task. Given the sample population of the present study, it would appear that secondary education mathematics teachers in the Mid-Hudson Valley region fall into either of two philosophic camps regarding the use of calculators in classroom instruction. An estimated

significant portion of teachers utilize them, while an almost equal significant portion of teachers do not.

Additionally, based upon the survey responses of only administrators, their data suggested that the apparent failure of teachers to utilize calculators in the classroom was correlated to teacher support of calculators as well as students not having calculators. That is based upon the data of participating administrators, responses to Question #5 and Question #3 were somewhat correlated to the responses to Question #4. On the other hand, based upon responses of the teachers, their data only suggested a somewhat singular correlation between Question #5 and Question #4, that is, the lack of teacher support for calculators as learning tools seemed correlated to the integration of calculators in the classroom.

Moreover, given the results of the chi-square analysis some differences in survey responses might be attributed to the educator's job and/or size of the school district surveyed. While not significant, the teacher and administrator responses to Question #8, in-service training, were statistically interesting ($p = 0.14$). While the responses to this question may be different as a result of the educator's job; it is not known if these results were due to true differences in the viewpoints of the participants, or if the teachers and administrators surveyed were from different school districts having divergent in-service training opportunities as the survey was conducted anonymously.

However, some conclusions might be drawn from the chi-square analysis of these questions when comparing responses from rural school district participants to those of urban schools. Results were statistically significant ($p = 0.05$) for Question #8, in-service training. Hence, it would appear that urban school districts, those having 800 or more students, offer more in-service teacher calculator training than rural districts. This result might shed some light on the difference previously noted for the same question when comparing responses of teachers and administrators. Also, while not significant, the chi-square results of Question #12, NCTM awareness, were statistically interesting ($p = 0.12$) when comparing the responses of rural and urban school participants. It might be that educators in smaller rural school districts, those having less than 800

students in grades nine through twelve, were more aware of NCTM's calculator recommendations. Nonetheless, based upon responses to the utilization of NCTM's calculator recommendation, usage appears to be approximately the same.

Given the statistically significant results of data and tests of the fourth hypothesis, the findings of this study appeared consistent with the work of Bitter and Hatfield (1993) who reported that the appropriate use of calculators "is still controversial (p.78)". They found that "participating teachers differed widely in the degree to which they integrated the calculator as suggested by NCTM (Bitter & Hatfield, 1993, p. 78)." Based upon the distribution of the cumulative responses to Question #5, 28.5% of the all survey responders estimated that 39%, or less, of the teachers supported the use of calculators as learning tools. This was compared to 57.1% of all participants who estimated that 60%, or more, supported the use of calculators. Additionally, when this same data was considered using only the responses of the teachers surveyed, the percentages changed to 36.0% of the teachers who estimated that 39%, or less, all district teachers supported the use of calculators. This was compared to 52.0% of the teachers who estimated 60%, or more, of all district math teachers supported the use of calculators. As was previously noted also, the distribution of responses for Question #4 was bimodal suggesting two distinct philosophic viewpoints on the use of calculators in the classroom. Perhaps this finding can best be summed up as follows.

In a sign of possible growing concern with the American educational system, O'Neil (1993) reported that the standards movement has recently won a significant number of supporters. He highlighted and praised the mathematical model developed by the National Council of Teachers of Mathematics, the *Curriculum and Evaluation Standards for School Mathematics*, which includes NCTM's position on classroom calculator usage. However, O'Neil noted that "despite the considerable efforts of NCTM and other mathematics groups, the impact of the standards has been mixed" (1993, p. 8). He suggested that many states have begun to revise their own curriculum frameworks to reflect NCTM's standards. O'Neil also reported that in a 1991 survey conducted by the National Council of Teachers of Mathematics, only 48% of grades 9-12 teachers were aware of NCTM's mathematics standards previously identified. Results of the present study indicated

that 88.1% of all survey participants reported an awareness to NCTM's calculator recommendations, and 57.1% of all participants reported utilizing them.

Within New York State, a 1994 Draft Report developed by Curriculum and Assessment Committee for Mathematics, Science, and Technology and the State Education Department staff reinforced the use of appropriate technology for instruction and assessment (New York State Education Department, March 5, 1994). However, as Romberg (1993), chairman of the commission that produced NCTM's *Curriculum and Evaluation Standards for School Mathematics*, suggested that while the impact of the *Standards* has exceeded expectations thus far, "only when the plans and new products are being used in the classrooms by teachers who own the philosophy and vision expressed in the *Standards* will real change begin to occur (italics added) (p. 39)."

Perhaps this was the most significant, and obvious, finding of the present study. Only when the teachers who are charged to implement change in a curriculum support that change, will the change effectively occur. This conclusion was supported statistically at a 0.05 level of significance by the Pearson correlation test of the fourth hypothesis. The cumulative data supported the correlation of Question #5, teacher support of the use of calculators, and Question #4, integration of calculators into the mathematics curricula. Finally as previously acknowledged, the present study did some note some differences in the survey responses of teachers and administrators, as well as, rural and urban school district participants. The extent to that any of the present study's findings can be generalized to larger educational populations will addressed below this study's limitations discussed below.

Limitations

This study's design limitations included the following. First, once approval to conduct the survey was received from the participating school district's superintendent, there was no control over the sample teachers that were selected to respond to the survey. Furthermore, there was a concern that the sample responders most willing to participate in this survey might have been

among the most favorable teachers regarding using calculators in the classroom, and therefore little perhaps information would be obtained on what obstacles teachers who do not fully utilize calculators in the classroom needed to overcome. That is, teachers most supportive of this topic might also have been the teachers most willing to participate in the survey, thus providing little information on what problems exist when calculators are used in classroom instruction. Additionally, as a result of utilizing a questionnaire, as opposed to an interview technique, questions on the calculator survey were subject to the individual interpretation of each participant. Hence, survey responses might have varied slightly based upon individual interpretations of the questions rather due to than true differences in views and practices on classroom calculator usage.

To the extent that only public school districts within a fifty mile radius of Marist college were surveyed, and private schools were not, results of this study might not be truly representative of all secondary education in the Mid-Hudson Valley region. Furthermore, prior to the beginning of the study, no attempt was made to assess how representative a sample from the Mid-Hudson Valley region would be compared to the remainder of New York State or other sections of the country. Consequently, due to the relatively small sample size and the fact no attempt was made to determine how representative this sample was of the greater populations of secondary education mathematics teachers, any generalizations about the findings of the present study must take these considerations into account. Furthermore, given the relatively small number of the survey sample participants, several of the results that were statistically interesting at a 0.10 significance level could have been statistically significant if the sample size was larger.

This study also had a heavy dependence upon materials and publications of the National Council of Teachers of Mathematics, such as NCTM's position statement on calculators in the classroom, and NCTM's journals and published books. A question still remains that was raised in the beginning of the present study, 'what percentage of American mathematics teachers does NCTM represent?' While the lack of an answer to this question did not diminish the value of utilizing calculators in the classroom as a useful learning tool, nor did it distract from the results reported by other independent researchers, one needs to deliberate how the voices of secondary

mathematics teachers, as an overall profession, are heard on this topic other than through the National Council of Teachers of Mathematics.

Recommendations

Additional research on this topic should consider the ensuing thoughts. The present study could be redone with the subsequent modification. Instead of soliciting input from a principal and mathematics teacher in each school district surveyed, data from two mathematics teachers per school district should be collected. One mathematics teacher should be a calculator advocate, while the other math teacher be less than supportive, or unconvinced of the benefits of utilizing calculators as learning tools. Additionally, data should be collected from a larger number of school districts. This revised study might better identify reasons why math teachers have apparently failed to implement calculators into classroom instruction despite significant educational research which supports the benefits of such a position. By comparing the results of these two different groups of mathematics teachers, a better understanding of calculator inhibitors might be reached.

A second study of potential interest to educators, who want to implement calculators into classroom instruction, would be to compile a list of resources that teachers could utilize to accomplish this task. For example, text books, such as *College Algebra Concepts and Models* by Larson, Hostetler, and Munn (1992), exist that have already integrated calculator activities as part of the normal instruction. Also, workbooks, such as *Advanced Calculator Math: (Grades 7-10)* by Vervoort and Mason (1980), exist which secondary education mathematics teachers could utilize to supplement normal classroom instruction with calculator activities. Moreover, there appear to be a growing number of in-service training programs being offered that address teaching mathematics with calculators. A potential source of in-service training programs might be had from organizations such as the National Council of Teachers of Mathematics and/or the Association of Mathematics Teachers of New York State. Likewise, by contacting calculator manufacturers, such as Texas Instruments, other potential resources might be uncovered. For example, Texas Instruments offers calculator lending programs, references lists, videos, etc. to

schools that want to learn more about the use of calculators. Future research on this topic could provide a service to teachers who wish to take advantage of calculators in the classroom but aren't sure how by providing a reference list of calculator resources for classroom instruction.

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Appendix A

Scientific calculator survey Page 1 of 2

(1) Please check one: Administrator: _____ Mathematics teacher: _____

(2) Estimate the student population of grades nine through twelve: _____

(3) Estimate the percentage of all district secondary mathematics students that have scientific calculators?

0-19%	20-39%	40-59%	60-79%	80-99%
1	2	3	4	5

(4) Estimate the percentage of all district secondary mathematics classes have integrated calculator usage into the course curricula, i.e. calculators are used routinely during instruction?

0-19%	20-39%	40-59%	60-79%	80-99%
1	2	3	4	5

(5) Estimate the percentage of all district secondary mathematics teachers that support the use of scientific calculators as part of their normal classroom instruction?

0-19%	20-39%	40-59%	60-79%	80-99%
1	2	3	4	5

(6) If calculators are utilized as part of math instruction, does teacher support exist, e.g. consultants, overhead projectors, etc? Yes _____ No _____

If not, what is lacking? Please identify below:

(7) Are calculators allowed during math tests? Yes _____ No _____

(8) Does your school district provide in-service teacher training on calculator usage? Yes _____ No _____

Appendix A

Scientific calculator survey Page 2 of 2

(9) What educational benefits, if any, do you believe result from using calculators in the mathematics curricula? Please list below:

(10) What problems, if any, do you feel need to be addressed to effectively utilize calculators in your math curricula? Please identify below:

(11) Does your school district have a stated policy regarding calculator usage in the classrooms? Yes _____ No _____

If yes, is it stated in writing and available to, and followed by, district teachers? Yes _____ No _____

If yes, who helped develop the policy, e.g. administrators, teachers, consultants, etc? Please identify below:

(12) Are you aware of the National Council of Teachers of Mathematics' (NCTM) position statement, and recommendations, on classroom calculator usage? Yes _____ No _____

If yes, does your district utilize them? Yes _____ No _____

Thank you for your participation!

Appendix B-1

Sept. 16th, 1994
Shokan, N.Y. 12481

Memorandum for: Calculator Survey Respondent - Permission

Dear Superintendent:

I am a graduate student at Marist College in Poughkeepsie, New York conducting a research project on the status of hand held nonprogrammable scientific calculators in secondary education throughout the Mid-Hudson Valley. The project is part of the requirements for completion of my M.A. in Educational Psychology.

I am requesting your approval to contact the high school principal and one mathematics teacher, via mail, in your school district seeking their voluntary participation in the study of calculator usage in secondary education. All raw data received will be treated as confidential, and will be destroyed upon completion of this project. No one, other than myself and my project advisor, Dr. David Rule of Marist College, will have access to this data. Only summary results, without any identity to participating school districts and individual participants, might ever be published.

Participation by employees of your school district is strictly voluntarily and any participant can skip any question that he/she chooses not to answer. I have enclosed a copy of the letter that I would like to send to your high school principal/mathematics teacher along with the sample calculator survey.

If you approve of this request, please sign this letter below and return it to me in the stamped self-addressed envelope provided. If you have any questions about the enclosed materials, please do not hesitate to contact me, or have someone on your staff contact me at any time.

Thank you in advance for your consideration and support on this matter.

Sincerely,

Edward D. Ostapczuk

_____

Superintendent Approval - School District

cc: Dr. David Rule, Marist College
encl.

Appendix B-2

Sept. 30th, 1994
Shokan, N.Y. 12481

Memorandum for: Calculator Survey Respondent - Permission, follow-up

Re: (1) My Sept. 16th letter to Superintendents, same subject

Dear Superintendent:

Recently I wrote to you seeking approval to contact two employees in your school district via mail soliciting their voluntary participation in the study of calculator usage in secondary education. I have contacted over forty-five school districts in the Mid-Hudson Valley on this survey. While the response to my request has been good, as yet, I have not received your permission to proceed with the survey in your school district.

As I indicated to you in my Sept. 16th letter, all data received will be treated as confidential, and will be destroyed upon completion of this project. The timely participation of your school district will help nurture educational research towards the enhancement of mathematics pedagogy in secondary education.

I want to reiterate that participation by employees of your school district is strictly voluntarily and any participant can skip any question that he/she chooses not to answer. Additionally, since the entire survey is autonomous, I have no method of identifying any survey responses from specific school district participants. Therefore, it is critical to the success of this study that I successfully secure the greatest number of potential participants as possible.

At this time, if you approve of this request, please sign this letter below, also noting your school district, and return it to me in the stamped self-addressed envelope provided. If you have any questions about this letter, or require another copy of the survey, please do not hesitate to contact me at any time.

Once again, thank you for your consideration on this matter. If you already have replied to my Sept. 16th letter, please ignore this follow-up and accept my sincere thanks for your support.

Sincerely,

Edward D. Ostapczuk

_____

Superintendent Approval - School District

cc: Dr. David Rule, Marist College

Appendix B-3

Sept. 23rd, 1994
Shokan, N.Y. 12481

Memorandum for: Calculator Survey Respondent

Dear High School Principal:

I am a graduate student at Marist College in Poughkeepsie, New York conducting a research project on the status of hand held nonprogrammable scientific calculators in secondary education throughout the Mid-Hudson Valley. The project is part of the requirements for completion of my M.A. in Educational Psychology.

I am seeking the participation of yourself and one of the mathematics teachers in your high school. Participation by yourself, and a staff member, is strictly voluntarily and any participant can skip any question that he/she chooses not to answer. All raw data will be treated as confidential, and will be destroyed upon completion of this project. No one, other than myself and my project advisor, Dr. David Rule, will have access to this data.

Please answer one copy of the enclosed survey and return it to me in the stamped self-addressed envelope. Please give the second copy of the enclosed survey, with its attached cover letter, to one of your mathematics teachers for their input along with a stamped self-addressed envelope.

Recent research has suggested that utilizing calculators in mathematics instruction may benefit student learning. Your timely participation in this survey will help foster additional educational research towards the enhancement of mathematics pedagogy in secondary education.

If you, or any of your staff, have any questions about the enclosed materials, please do not hesitate to contact me. Thank you in advance for your consideration and support on this matter.

Sincerely,

Edward D. Ostapczuk

cc: District mathematics teacher
Dr. David Rule, Marist College

encl.

If you would like a summary copy of the results upon completion of this study, send me your name and address. While your request may compromise your anonymity, your confidentiality will be preserved.

Appendix B-4

Oct. 8th, 1994
Shokan, N.Y. 12481

Memorandum for: Calculator Survey Respondent - follow-up

Re: My Sept. 23rd letter to High School Principals, same subject

Dear High School Principal:

This is a follow-up to my Sept. 23rd letter soliciting your voluntary participation in the secondary education scientific calculator usage study. Over forty-five school districts throughout the Mid-Hudson Valley were contacted regarding this survey. Since all responses to this survey are confidential, and anonymous, I have no means of knowing who has returned a survey, and who has yet had the opportunity to complete one. Hence, this follow-up letter is being sent to all the principals of school districts where permission to solicit input was granted by the district superintendent.

If you have completed your survey, **Thank You!** If you have not had the opportunity to do so yet, would you consider completing one at this time? The survey is very short and shouldn't take very long to complete. Your timely participation will assist my project and educational research in general.

Also, since you are the sole conduit to the survey mathematics teacher in your school district, would you kindly pass along a copy of this letter to the same mathematics teacher that you first discussed this survey with.

By copy of this letter, I am reminding all voluntary participants that I require their surveys by Oct. 17th if at all possible, however, I will accept input after that date. I have enclosed two stamped self-addressed envelopes for use, if necessary, and one additional copy of the survey in case the original copy was misplaced.

Once again, I want to thank both of you for your consideration on this matter. If you have already completed the survey, please ignore this follow-up letter and accept my sincere thanks for your support. If you have yet to complete the survey, please consider doing so now. **Thank you!**

Sincerely,

Edward D. Ostapczuk

cc: District mathematics teacher
Dr. David Rule, Marist College
encl.

Appendix C

	Pearson Correlation Coefficient	Significance
Cumulative responses:		
#3 - students with calculators	0.171	0.146
#5 - teachers who support calculators	0.298	0.029
Teacher responses:		
#3 - students with calculators	0.088	0.341
#5 - teachers who support calculators	0.281	0.092
Administrator responses:		
#3 - students with calculators	0.289	0.139
#5 - teachers who support calculators	0.338	0.092
Rural responses:		
#3 - students with calculators	0.229	0.147
#5 - teachers who support calculators	0.176	0.205
Urban responses:		
#3 - students with calculators	-0.009	0.487
#5 - teachers who support calculators	0.411	0.057

	t-tests		
	t	df	Significance
Cumulative responses:			
#3 - students with calculators	-1.13	30	0.267
#5 - teachers who support calculators	-0.86	33	0.397
#6 - support services	-0.13	37	0.894
#8 - in-service training	1.41	39	0.166
#11 - district policy	-1.00	39	0.326
#12 - NCTM awareness	-0.48	39	0.636
Teacher responses:			
#6 - support services	0.30	21	0.770
#8 - in-service training	1.28	22	0.212
#11 - district policy	-1.80	22	0.086
#12 - NCTM awareness	N/A	22	N/A
Administrator responses:			
#6 - support services	-0.70	14	0.493
#8 - in-service training	0.75	15	0.464
#11 - district policy	0.73	15	0.475
#12 - NCTM awareness	-0.73	15	0.475

BEST COPY AVAILABLE

Appendix D - 1

Cumulative responses - Question #3: students with calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	34.1%	34.1%
20-39%	2	36.6%	70.7%
40-59%	3	19.6%	90.3%
60-79%	4	7.3%	97.6%
80-99%	5	2.4%	100.0%

Cumulative responses - Question #4: classes that integrated calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	24.4%	24.4%
20-39%	2	22.0%	46.4%
40-59%	3	12.1%	58.5%
60-79%	4	22.0%	80.5%
80-99%	5	19.5%	100.0%

Cumulative responses - Question #5: teachers who support calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	7.1%	7.1%
20-39%	2	21.4%	28.5%
40-59%	3	14.4%	42.9%
60-79%	4	19.0%	61.9%
80-99%	5	38.1%	100.0%

Appendix D - 2

Teacher responses - Question #3: students with calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	36.0%	36.0%
20-39%	2	40.0%	76.0%
40-59%	3	16.0%	92.0%
60-79%	4	8.0%	100.0%
80-99%	5	0.0%	100.0%

Teacher responses - Question #4: classes that integrated calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	25.0%	25.0%
20-39%	2	25.0%	50.0%
40-59%	3	8.3%	58.3%
60-79%	4	16.7%	75.0%
80-99%	5	25.0%	100.0%

Teacher responses - Question #5: teachers who support calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	8.0%	8.0%
20-39%	2	28.0%	36.0%
40-59%	3	12.0%	48.0%
60-79%	4	12.0%	60.0%
80-99%	5	40.0%	100.0%

Appendix D - 3

Administrator responses - Question #3: students with calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	31.3%	31.3%
20-39%	2	31.3%	62.6%
40-59%	3	24.8%	87.4%
60-79%	4	6.3%	93.7%
80-99%	5	6.3%	100.0%

Administrator responses - Question #4: classes that integrated calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	23.5%	23.5%
20-39%	2	17.6%	41.1%
40-59%	3	17.6%	58.7%
60-79%	4	29.4%	88.1%
80-99%	5	11.9%	100.0%

Administrator responses - Question #5: teachers who support calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	5.9%	5.9%
20-39%	2	11.8%	17.7%
40-59%	3	17.6%	35.3%
60-79%	4	29.4%	64.7%
80-99%	5	35.3%	100.0%

Appendix D - 4

Rural district responses - Question #3: students with calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	37.5%	37.5%
20-39%	2	37.5%	75.0%
40-59%	3	12.5%	87.5%
60-79%	4	8.3%	95.8%
80-99%	5	4.2%	100.0%

Rural district responses - Question #4: classes that integrated calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	20.8%	20.8%
20-39%	2	29.2%	50.0%
40-59%	3	8.3%	58.3%
60-79%	4	25.0%	83.3%
80-99%	5	16.7%	100.0%

Rural district responses - Question #5: teachers who support calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	4.0%	4.0%
20-39%	2	20.0%	24.0%
40-59%	3	12.0%	36.0%
60-79%	4	24.0%	60.0%
80-99%	5	40.0%	100.0%

Appendix D - 5

Urban district responses - Question #3: students with calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	25.0%	25.0%
20-39%	2	37.5%	62.5%
40-59%	3	31.2%	93.7%
60-79%	4	6.3%	100.0%
80-99%	5	0.0%	100.0%

Urban district responses - Question #4: classes that integrated calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	25.0%	25.0%
20-39%	2	12.4%	37.4%
40-59%	3	18.8%	56.2%
60-79%	4	18.8%	75.0%
80-99%	5	25.0%	100.0%

Urban district responses - Question #5: teachers who support calculators

Estimated Percent	Likert Scale	Percentage of Responses	Cumulative Percentage Responses
0-19%	1	12.5%	12.5%
20-39%	2	18.8%	31.3%
40-59%	3	18.8%	50.1%
60-79%	4	12.5%	62.6%
80-99%	5	37.4%	100.0%

Appendix E

	Cumulative Percent Yes	Cumulative Percent No
Question #:		
#6 - support services	77.5%	22.5%
#7 - math tests	85.4%	14.6%
#8 - in-service training	28.6%	71.4%
#11 - district policy	19.0%	81.0%
#12 - NCTM awareness	88.1%	11.9%
#12 - NCTM utilization	57.1%	42.9%

	Teachers Percent Yes	Teachers Percent No	Admin. Percent Yes	Admin. Percent No
Question #:				
#6 - support services	75.0%	25.0%	81.3%	18.7%
#7 - math tests	91.7%	8.3%	76.5%	23.5%
#8 - in-service training	20.0%	80.0%	41.2%	58.8%
#11 - district policy	20.0%	80.0%	17.6%	82.4%
#12 - NCTM awareness	92.0%	8.0%	82.4%	17.6%
#12 - NCTM utilization	56.0%	44.0%	58.8%	41.2%

	Rural Percent Yes	Rural Percent No	Urban Percent Yes	Urban Percent No
Question #:				
#6 - support services	78.3%	21.7%	81.3%	18.7%
#7 - math tests	87.5%	12.5%	81.3%	18.7%
#8 - in-service training	16.0%	84.0%	43.8%	56.2%
#11 - district policy	20.0%	80.0%	18.7%	81.3%
#12 - NCTM awareness	96.0%	4.0%	81.3%	18.7%
#12 - NCTM utilization	56.0%	44.0%	62.5%	37.5%

Appendix F

Chi-square values

	Phi Value	Significance
Teacher/administrator responses:		
#6 - support services	0.073	0.643
#7 - math test	0.212	0.175
#8 - in-service training	0.230	0.136
#11 - district policy	0.029	0.849
#12 - NCTM awareness	0.146	0.343
#12 - NCTM utilization	0.015	0.928
Rural/urban responses:		
#6 - support services	0.036	0.820
#7 - math test	0.086	0.588
#8 - in-service training	0.306	0.050
#11 - district policy	0.015	0.922
#12 - NCTM awareness	0.242	0.121
#12 - NCTM utilization	0.015	0.928

t-tests

Question #4 - classes that integrated calculators:
Mean survey responses of Q #4 for:

	t	df	Significance
Teachers vs. administrators	-0.07	39	0.943
Rural vs. urban districts	-0.39	38	0.701

Appendix G

Educational benefits - Question #9

Responses:	Number of responses	Percent of participants
Improved problem solving & math concepts	22	51.2%
Reduced computation time	19	44.2%
Ability to teach more complex problems	13	30.2%
Students learning with technology	10	23.3%
Improved student attitudes towards math	7	16.3%
Improved accuracy	4	9.3%
Increased exploration	3	7.0%
Improved checking/estimation	2	4.7%

Educational problems - Question #10

Responses:	Number of responses	Percent of participants
Costs of calculators/equity	9	20.9%
Staff training/encouragement	7	16.3%
Appropriate standards on usage & calculator functions	7	16.3%
Student math skill degradation	6	14.0%
Calculator in-service training	6	14.0%
Public acceptance of the use of calculators	6	14.0%
Supporting math texts	3	7.0%
Student skills - knowing when to utilize calculators	3	7.0%
Math curriculum revisions	3	7.0%

Edward D. Ostapczuk
69 Ridge Road
Shokan, NY 12481
(914) 657-6393

OBJECTIVE: Career in education teaching mathematics/science.

QUALIFIED BY: Extensive math knowledge, engineering experience, and youth involvement; Teaching experience gained via adjunct instruction, substitute teaching, community service work, in-service seminars, and adult education. Multiple NYS secondary education teaching certifications.

CERTIFICATIONS: NYS 7-12 MATHEMATICS, PHYSICS, & GENERAL SCIENCE

EDUCATION:

M.A., EDUCATIONAL PSYCHOLOGY
Marist College, Poughkeepsie, NY (4.0/4.0 GPA)

M.S., MANAGEMENT/OPERATIONS RESEARCH
Rensselaer Polytechnic Institute, Troy, NY

B.S., INDUSTRIAL ENGINEERING, Magna Cum Laude,
Elected to Four Top Academic and Leadership Honor Societies
Newark College of Engineering, Newark, NJ

ENGINEERING/PROGRAMMING/MANAGEMENT DEV. - 650 Hrs.
IBM Corporation

EXPERIENCE: **Instructional Background**

Professional Services:

Onteora High School, Boiceville, NY - Substitute Teaching 1993-1994

Franklin Delano Roosevelt High School, Hyde Park, NY - Student Teaching 1994
Taught two non-regents course 1, one course 3 honors, and two AP AB/BC calculus classes. Experience included team teaching design of math tests & work puzzles to assess student learning, and need to adjust teaching methodologies to various levels of student abilities and interests. Responsible for course 1 progress reports and marking period grades.

Poughkeepsie Middle School, Poughkeepsie, NY - Student Teaching 1994
Taught two eighth grade and team taught two self-paced individualized mathematics classes in a diverse multi-cultural environment.

Marist College, Poughkeepsie, NY - Adjunct instructor, mathematics 1994
Taught Introductory Algebra utilizing modified cooperative learning approach.

Dutchess Community College, Poughkeepsie, NY - Adult education 1994
Taught fly fishing, developed course syllabi, utilized peer tutoring.

Beaverkill Valley Inn, Lew Beach, NY - Summer camp counselor 1994
Developed and implemented camp program for high school students that included many overnight and adventure trips, such as canoeing.

North Country Sports, North River, NY - Fly fishing instructor 1993-1994
Developed course syllabi; student ages ranged from teenager to senior citizens.

Self-employed, Fly fishing guide 1993-1994
Certified in first aid and CPR

Contributed Service:

Bennett Elementary School, Boiceville, NY - Teacher Aid, Esopus Streamwatch 1993-1994
Provided field instruction about water quality and implications on aquatic life.
Sunday school teacher 1983-1993
Taught junior and senior high school students.
Trout Unlimited - Fly tying/fly fishing instruction 1979-1994

Business/Technical Background

IBM Corporation, Kingston, NY - Senior Programmer (Manager) 1970-1993
A series of increasing responsible individual contributor and management positions in manufacturing, engineering, and programming emphasizing technical leadership, project control, and customer interaction. Selected for Executive Resource Program, and earned several monetary awards in recognition of strong performance.

PROFESSIONAL AFFILIATIONS: National Council of Teachers of Mathematics

RELATED ACCOMPLISHMENTS:

Extensive math competence gained via IBM programming assignments and 61.5 undergraduate and graduate college credits (3.41/4.0 GPA). Science competence gained via 41.5 undergraduate credits (3.33/4.00), engineering experience, and environmental activities for which I received regional and national recognition.

Performed extensive youth work via community service activities:

- Onteora Bath Ruth Baseball, Secretary, Asst. Coach, Public Relations 1989-1994
- Belleayre Bash - Onteora High School SADD, Volunteer 1992-1993
- Troop 69 Boy Scouts, Merit Badge Counselor, Advancement 1986-1992
- Town of Olive Basketball 5th/6th Grade, Coach 1989-1990
- Town of Olive Little League, Assistant Coach 1985-1990
- Pack 169 Cub Scouts, Assistant Cub Master, Webelo Den Leader 1984-1989
- Instructional Baseball, League Coordinator/Coach 1980-1984

Published author.

Demonstrated computer literacy; IBM software design and development experience.

Demonstrated excellent communication, problem solving, counselling, and evaluation skills, as well as, high degree of adaptability and leadership.

Provided IBM in-service training on management and software topics.

Succeeded at variety of life experiences: management, engineering, programming, manufacturing, teaching, coaching, surveying (U.S. Army), published author, NYS Licensed Guide.